White Pine Blister Rust
Why Here, Why Now, What Next?

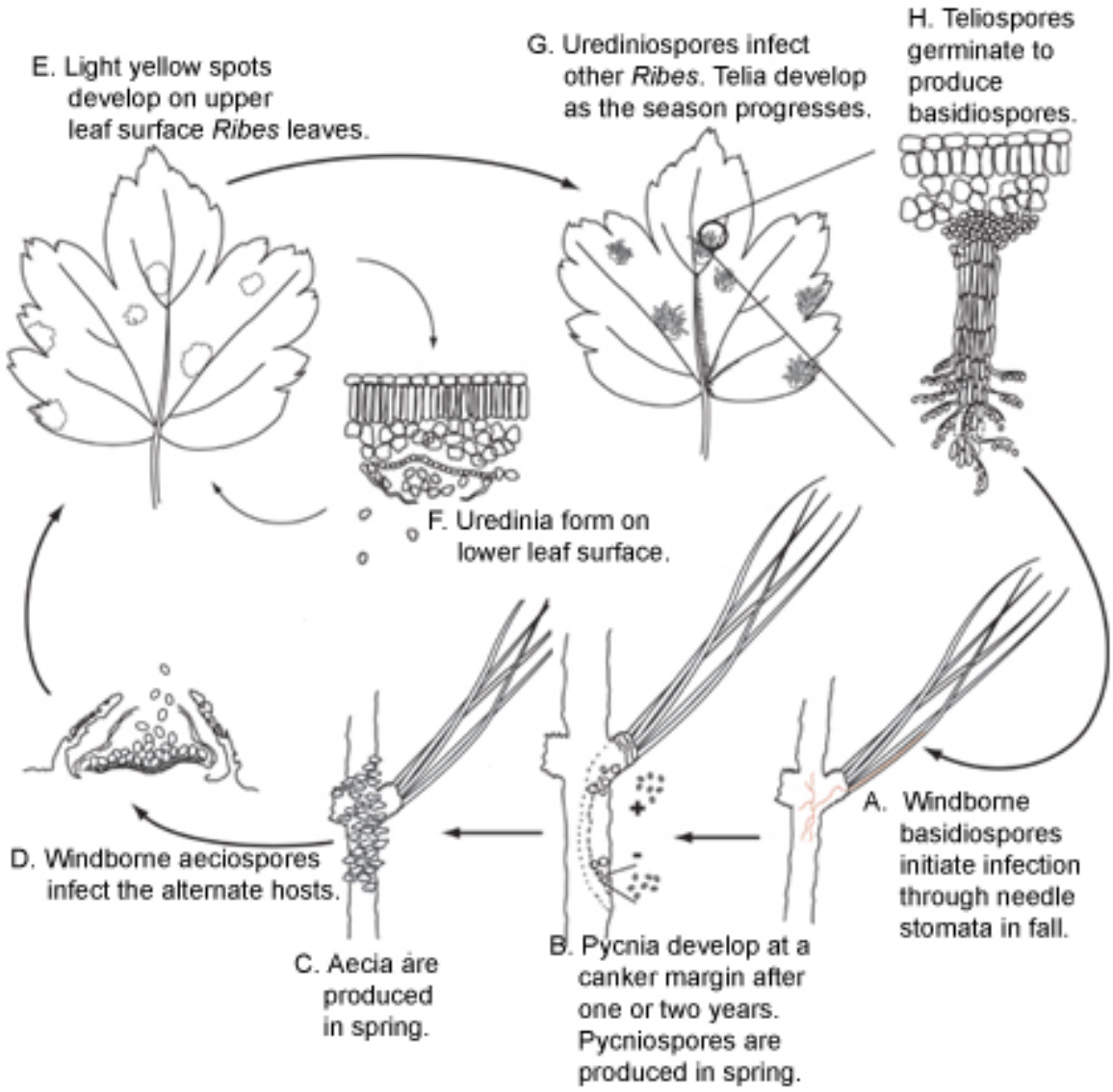
Everett Hansen

Department of Botany and Plant Pathology, Oregon State University, Corvallis. OR 97331

White pine blister rust is caused by the stem rust fungus *Cronartium ribicola*. It infects species of 5-needled pines, and the North American "soft" pines are particularly susceptible. The center of evolutionary origin for *Pinus* is evidently North America, where 69 species are recognized today. Asia is a secondary center of diversity for the genus, with about 38 species. The 5-needled pines of *Pinus* section *Strobus* are also concentrated in North America. Not unexpectedly, North America is the center of diversity for *Cronartium*, the pine stem rusts. These biotrophic pathogens have evolved with their host pines, and as with most co-evolved symbiotic interactions, host and pathogen maintain a rough detante—native rusts do not threaten the ecological standing of the native pines they parasitize.

When transported beyond the constraints of environment and host genetics, however, rust fungi, like many pathogens, have the potential for devastating impact. *C. ribicola* provides textbook example. White pine blister rust is native to eastern Asia. It is reportedly not difficult to find on Asian 5-needled pines, but seldom kills trees in its native home. It was introduced to Europe, probably in the early 1700s, where it proved destructive on *P. strobus* which was widely planted at the time. In the late 1800s or early 1900s it was transported to North America. Twice. Despite the evident threat to North American species, first eastern white pine seedlings and later western white pine seedlings, raised in European nurseries and exposed to blister rust, were imported to this country for forest outplanting. After damage was reported in the United States quarantines were imposed, but too late.

Today, blister rust occurs throughout the range of eastern white pine, and in the west, it has killed most of the western white pine and sugar pine in the northern parts of their ranges. It continues to intensify on the high elevation species, white bark and limber pine, and is still spreading south and east in the western mountains. The endemic white pines of Mexico and Central America are next in line.



White Pine Blister Rust Disease Cycle (Drawing by Vickie Brewster).

The life cycle of the pine rusts, including white pine blister rust, is long and complex. Five separate spore stages, on two unrelated host species, are needed to initiate a new generation. At each stage critical environmental conditions must be met, and host tissue at the appropriate stage of development must be available. It is easy to understand why damage is limited in co-evolved ecosystems. In western North America, however, *C. ribicola* found favorable environments, white pines that generally lacked useful resistance, and new, widely distributed alternate hosts.

Because of the economic as well as the ecological values of the white pines, efforts to reduce losses from blister rust have continued for nearly 100 years. The first quarantines were imposed too late, and were too limited to prevent the first introductions to North America. Quarantine protections are still important, however. There are evidently

different pathogenic races of the pathogen in eastern Asia today, with different alternate hosts, than the races that were introduced here years ago. We don't want those new races; we have trouble enough with the limited rust gene pool that we already face.

The textbook control for long-cycled rusts like wheat stem rust, and blister rust, is removal of the alternate host. The theory is sound, and phenomenal efforts were made, but ribes eradication didn't put a measurable dent in the blister rust epidemic in the west. In the eastern United States, however, where less robust topography makes spore dispersal more predictable, ribes eradication continues to be a practical tool in areas where the overall rust hazard is moderate or low. It may be useful in the west in special cases, perhaps in areas where the environment is marginal for the rust, or where resistant pine selections are deployed.

Pruning also offers useful protection where rust hazard is not extreme. Preventative pruning of lower branches, to remove the tissue most likely to be initially infected, or targeted canker pruning cutting off infected branches before cankers reach the main stem where they will kill the tree, are labor intensive but may be useful tools in high value situations.

Tree resistance is the disease control strategy of choice, however. Individual resistant trees have been found in all of the North American 5-needled pines, and active resistance selection and breeding programs continue for *P. strobus, P. monticola,* and *P. lambertiana*. Aggressive efforts are underway to find and exploit resistance in *P. albicaulace*. There have been many frustrations, and even embarrassing failures along the way, but lessons have been learned. While evolution of resistance is the tree's natural strategy, so too is evolution of new virulence genotypes the way of the fungus. Paradoxically, to be durable, that is to be

successful in the long run, tree resistance, and the breeding and outplanting programs that enhance it, must allow for the continued survival of the pathogen as well.

One hundred years of blister rust in North America have spawned 100 years of research, and we understand this disease better than most others. Surprises still come around, though, and new directions hold promise for new and better protections. The recent demonstrations of additional alternate hosts for *C. ribicola* in North America and of hybridization between *C. ribicola* and the native *C. comandrae* on limber pine were dramatic surprises. Characterization and better utilization of "slow rusting" types of resistance in more species of 5-needled pines may allow establishment of pine populations more like the co-evolved populations found in areas where rust and pine are both indigenous. Now, if we can keep whitebark pine from being pushed off the top of the mountains by warming climates……..